Invertebrate Conservation News

Number 73 March 2014

ISSN 1356 1359

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A publication of The Amateur Entomologists' Society

The Amateur Entomologists' Society

Founded in 1935

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INVERTEBRATE CONSERVATION NEWS

No. 73, March 2014

EDITORIAL

At the time of writing (mid-February) flooding is present in many parts of the UK, following months of exceptionally wet and stormy weather. This has brought misery for people whose homes or livelihoods are seriously affected and their plight has sparked debate about the balance between the need for artificial flood defences and the principle of re-establishing more natural systems of water storage, which allow flooding to occur in certain areas while helping to regulate flow in rivers and protecting wetland habitats.

Although seasonal flooding is normal in certain areas, extreme and prolonged flooding can affect invertebrates adversely, especially where there is a lack of floating material (e.g. pieces of dead wood) that can serve as refugia for overwintering species. Since, however, we are unlikely ever to know the effects of the present flooding on invertebrate communities, there is little more that can be said about it in *ICN*.

On another watery theme, this issue of *ICN* includes articles about the standard toxicity tests that are used to assess the effects of particular pesticides on non-target aquatic invertebrates. Official approval can be withheld or withdrawn from pesticides that are shown to be especially harmful according to such tests. But, as mentioned in recent *ICN* articles about neonicotinoid insecticides, some of the standard toxicity tests fail to reveal the full impact of pesticides on the species used in the tests, let alone other species that are not tested.

As in the case of bees affected by neonicotinoid insecticides, there

can be non-lethal effects that escape detection if tests measure only the incidence of acute harm or mortality. Certain non-lethal effects, such as a reduction in reproductive success, can be tested fairly satisfactorily in various species but less so in those that have long and complex life cycles. More subtle effects, which for example can involve disturbance of invertebrate behaviour, are inherently difficult to measure. Behavioural effects have been implicated in the so-called colony collapse disorder of honeybees but there are difficulties in obtaining reliable evidence because of the involvement of interacting factors, including debilitation caused by parasites and diseases.

Research is now providing evidence that the standard testing of pesticides sometimes fails to reveal their full impact on non-target species, even where the tests are designed to measure non-lethal effects such as reduced reproductive success. As mentioned in the *ICN* article below about research in Belgium, one of the problems is that standard tests are not carried out on all the stages of the life-cycles of the test species. Other research indicates that the impact of pesticides on communities of non-target aquatic invertebrates can be influenced by other commonly occurring factors, such as nutrient enrichment from farmland.

There is clearly cause for concern that the impact of pesticides on non-target species has not been assessed sufficiently to identify those products that are hazardous enough to warrant being withdrawn from use. In certain instances, the balance of evidence leads to restrictions being placed on certain pesticides, as in the case of various neonicotinoids in Europe. Meanwhile, however, other pesticides with the potential to cause serious harm will continue to be used in order to help feed a growing human population or to protect people from arthropod-transmitted diseases.

Finally, on a more mundane matter, the Amateur Entomologists' Society hereby informs *ICN* readers that the frequency of publication has been changed in order to fit in with the new quarterly frequency of the AES Bulletin. In 2014, *ICN* is therefore scheduled to appear only twice; in March and September, rather than thrice, but with an increased number of pages per issue. The plan is to increase the frequency to quarterly in 2015 if achievable.

NEWS, VIEWS AND GENERAL INFORMATION

Invasive species: proposed legislation in UK

The Law Commission has recently released a report entitled *Wildlife Law: Control of Invasive Non-native Species*, which recommends new regulations for the control of invasive species in England and Wales. The report forms part of the Commission's review of wildlife law, which has also included an interim report on the law as a whole. Meanwhile, there has also been an international consultation on European Union regulations relating to alien invasive species.

Alien invasive species can seriously harm native fauna and flora through competition, predation or the causation of disease (for example, as in the case of the fungi that cause crayfish plague or ash dieback disease). Disease-causing species (pathogens) are, however, covered by plant or animal health regulations and are not included in the new Law Commission report.

The Law Commission's new recommendations would emulate provisions that already exist in Scotland, conferring powers to impose 'control agreements' and 'control orders'. Such orders would be served on the owners or occupiers of sites in which particular invasive species have been reported. These might, for example, include invertebrates such as the 'Killer shrimp' *Dikerogammarus villosus* (see *ICN* Nos. 64, 66 and 68). The recommendations do not impinge inappropriately on the possession of exotic invertebrates as pets or for private study but there are already laws that prohibit the release (or permitted escape) of exotic invertebrates into the wild. The Law Commission report is available at: http://lawcommission.justice.gov.uk/docs/lc342_wildlife.pdf

Brownfield habitats: guidance on how to destroy them?

According to a report last year in News Alert Issue 39 (14 May 2013) of the EU Science for Environment policy, a new 'tool' has been developed in order to evaluate brownfield sites for their suitability for redevelopment (Chrysochoou *et al.*, 2012). Unlike existing methods, which are said to be designed for specific projects, the new tool is designed to help compare different brownfield sites over a large area

with the aim of deciding which ones to develop. The criteria include a 'socio-economic index', a 'smart growth index' (based on factors like availability of transport, access to utilities and employment opportunities) and an 'environmental index'.

In the context of the first item in "Sites and species of interest" below, which mentions a Buglife survey of the rapid loss of brownfield habitats, readers might suppose that the 'environmental index' of the new tool is at least partly intended to help decide whether particular sites have sufficient habitat value to warrant protection from unsuitable development. This is not, however, the purpose of the 'environmental index'. It appears to be solely concerned with factors that directly affect the economic and social value of the candidate sites for development. On the positive side, proximity to a park would enhance the environmental score, while indicators of soil contamination or susceptibility to flooding would detract from the score. Biodiversity is not mentioned in the News Alert article.

Reference

Chrysochoou, M., Brown, K., Dahal, G. *et al.* (2012). A GIS and indexing scheme to screen brownfields for area-wide redevelopment planning. *Landscape and Urban Planning* **105**,187-198.

Ash dieback: an ecological impact assessment for the UK

At the last count, ash dieback caused by the alien invasive fungus *Hymenoscyphus pseudoalbidus* (= *Chalara fraxinea*) had been recorded at 609 sites in the UK. At 238 of those sites, the disease has affected 'ash trees in the wider environment'; i.e. part of the existing ash population, rather than imported trees that have been planted in recent years. If the disease progresses through our ash population as it has in other European countries, such as Sweden, there will be serious cause for concern on many fronts, including the potential for decline or extinction of species associated with ash.

The Joint Nature Conservation Committee has recently published a report on the ecological impact of ash dieback (Mitchell *et al.*, 2014). With 31 authors from a range of backgrounds, the report brings together knowledge of a range of the ecological roles of ash trees in the UK. There is a description of the overall ecological 'function' of ash

trees, including nutrient cycling and the role of ash in the woodland succession. Also, there are lists of the species associated with ash, some of which are totally dependent, while others are capable of using other tree or shrub species. The central chapters of the report deal with the main taxa of the species associated with ash, identifying in each case those species that are likely to become rare because of ash dieback, because they depend either wholly or largely on ash. The listed taxa are as follows:

- Vascular plants
- Lichens
- Bryophytes (liverworts and mosses)
- Fungi
- Invertebrates, with particular reference to Lepidoptera, Diptera and Coleoptera
- Mammals, including bats
- Birds

The report then returns to the overall appraisal of species in relation to their dependence on ash. Of 239 invertebrate species that are identified as being associated with ash, 29 are classed as occurring only on ash trees, either living or dead. A further 24 species are classed as 'highly associated' with ash. Of the remainder, 19 are classed as using ash trees, while 131 are termed cosmopolitan. Using the degree of ash-dependency as a measure of the risk posed by ash dieback, the authors conclude that lichens are the taxonomic group most at risk, followed by invertebrates and bryophytes. They assess the risk also in an alternative way; by grouping all the species according to their designated conservation status, if any. On this basis, invertebrates collectively appear to be more at risk from ash dieback than any of the other taxonomic groups.

The report also includes a number of different analyses of the capacity of various tree species to sustain species that depend partly on ash. One of these analyses indicates that, of twelve tree species under consideration, none supports more than 300 of the 953 species that are classed as using ash. The same analysis indicates that the most

suitable species include oak (either pedunculate or sessile), beech, sycamore and hazel but the different methods of analysis produce very different rankings. Tree species-mixtures are discussed as a means of plugging the gaps that would be left by over-reliance on single species as substitutes for ash.

The report has been criticised for a failure to emphasise the importance of wood decay habitats provided by ash trees, especially those that are ancient and thus support certain invertebrates that occur only at sites where there has been habitat-continuity for many centuries. The decaying wood habitat is, however, mentioned in various parts of the report, mainly in relation to the recognition of species dependent on ash.

Reference

Mitchell, R. J., Bailey, S., Beaton, J. K., *et al.* (2014). The potential ecological impact of ash dieback in the UK. *JNCC Report* No. 483.

Other threats to ash trees

The fungus *Hymenoscyphus pseudoalbidus* is not the only unwelcome visitor from east Asia. There is cause for concern also about the Emerald Ash Borer *Agrilus planipennis*, a buprestid beetle which has already caused havoc in North America, where it probably arrived in wooden packing materials through international trade. Subsequent spread has probably been facilitated by the distribution of firewood and other material with bark attached. The cost of felling and replacing ash trees in N. America has, so far, reached an estimated total of $10 billion. The reason for concern in Europe, including the UK, is that the beetle has also been introduced into European Russia and can now be found well to the west of Moscow.

The larvae of *Agrilus planipennis,* like those of other buprestids, feed by burrowing in the inner bark (phloem), often girdling and thus killing the tree within about three years. In North America, all sizes of ash tree are affected. Interestingly, it is a North American ash species, *Fraxinus pennsylvanica*, that has been affected in the Moscow area of Russia. It is not clear whether the native ash of north-western Europe, *F. excelsior*, will prove so susceptible.

A lack of natural enemies might partly explain the impact of *A. planipennis* in N. America, and so attempts are being made to find such enemies in the natural range (east Asia).

It is perhaps of less concern that yet another alien invader has been on ash trees in the UK. This is the 'ash mirid plant bug' *Tropidosteptes pacificus*, a native of western North America, originally described as *Neoborus pacificus*. In 2012, it was found at Alexandra Park in north London, producing hundreds of individuals in a second generation, and at a site in South Kensington, west London (Bantock & Stewart, 2013; Nau, 2013; Stubbs, 2013). It has also been found in the Netherlands and Belgium.

The bug appears well suited to the climate of most of the UK and disperses readily by flight. It can also be unwittingly transported with ash plants, since the eggs are almost undetectable, inside petioles or bark. By feeding on the buds, leaves, seeds and young twigs, it can cause premature defoliation and is classed as a pest in the USA. Its capacity to cause harm is, however, probably less than that of *A. planipennis*. In the Netherlands, where it has been established for at least 6 years, it has not had any significant economic, environmental or social impact.

References

Bantock, T. & Stewart, A. (2013). *British Wildlife* **24**, 277.

Nau, B. (2013). Species Reports. Miridae. *Tropidostethus pacificus* (Van Duzee,1921). *Het News* **19/20**, 9.

Stubbs, A. 2013. Heteroptera & *Chalara* dieback disease of Ash (*Fraxinus excelsior*). *Het News* **19/20**, 6.

No overall change in use of DDT in recent years

A conservation stand has been a feature of the AES annual exhibition for many years. The themes displayed have included the effects of pesticides on non-target invertebrates. A photograph of a packet of DDT (dichloro-diphenyl-trichoroethane) used to be displayed for emphasis. Owing to prolonged persistence in food chains, DDT was withdrawn from use in many western countries many years ago. As far back as the mid 1970s, a visitor to the AES Conservation stand complained that the depiction of DDT was misleading, since newer

and less persistent pesticides had replaced it. He mentioned that he had worked for an agro-chemical company.

Bearing in mind that it is nearly 40 years since the AES conservation stand was criticised for being out of date with regard to DDT, it is interesting to see a recent report that shows that this chemical is still used on a large scale in some parts of the world. The report states that there was no substantial change in its use from 2000 to 2009 to control the insect vectors of diseases such as malaria. The report mentions also that pyrethroid insecticides, also widely used against disease vectors, are losing effectiveness because of tolerance in the target species.

The report is based on data from 125 countries, which were controlling vectors of various diseases, with malaria, dengue fever, leishmaniasis and Chagas disease being the most targeted, in that order. Although pyrethroids accounted for 81% of the surface area sprayed, the total amount of organochlorine insecticides (mainly DDT) was greater, accounting for 71% of the total (these figures did not include the use of pyrethroids to treat the fabric used for mosquito nets). Of the total amount of DDT applied over the period, South-East Asia used an average of 3,623 tons of active ingredient per year, with the remainder being applied in Africa.

Reference

van der Berg, H., Zaim, M., Yadav, R.S. *et al.* (2012). Global trends in the Use of Insecticides to Control Vector-Borne Diseases. *Environmental Health Perspectives* **129**, 577-582.

SITES AND SPECIES OF INTEREST

Brownfield habitats near London: destruction and threat

A recent report from Buglife – The Invertebrate Conservation Trust, reveals worrying findings from a survey of brownfield sites in the Thames Gateway, an area of rapid economic development near the Thames Estuary, east of London. The survey looks at the current status of 198 sites that were previously surveyed during 2005-07 in Buglife's "All of a Buzz in the Thames Gateway" project (Robins, 2013). Buglife summarises the new results as showing that 51% of these sites, which are (or were) of high and medium importance for invertebrates have been "*lost, damaged or are under immediate threat*".

Brownfield sites can be very rich in invertebrate species, owing to a combination of attributes such as low-nutrient soils, imported substrates and periodic disturbance, which allow the development of a diverse and complex mosaic of plant communities and soil structure. The report refers to earlier findings that brownfield sites in the UK are comparable to ancient woodland in respect of invertebrate species-richness. Such sites support an estimated 12-15% of the UK's nationally rare and scarce invertebrates, some of which are not found at any other UK sites.

The report points out that over 100 Red Data Book (RDB) species and over 400 Nationally Scarce species have been recorded on brownfield sites in the Thames Gateway. These species include about 15 of the invertebrates on the UK Biodiversity Action Plan Priority list, including the Streaked Bombardier Beetle *Brachinus sclopeta*, the Distinguished Jumping Spider *Sitticus distinguendus* and the Shrill Carder Bee *Bombus sylvarum*. The Thames Gateway also supports a remarkable number of rare and scarce bees and wasps, including 74% of the UK national fauna. Despite all this, brownfield sites are often seen as "wastelands" and of little conservation value.

The report reminds us that two of the top five most species-rich sites in the UK are brownfields, both of these being in the county of Essex. Canvey Wick, the site of a former oil refinery, supports more recorded species per unit area than any other site in the UK and is now a Site of Special Scientific Interest (SSSI), designated for its invertebrate fauna.

West Thurrock Marshes (see *ICN* Nos. 52 and 58), which contained a former power station, is home to over 1,200 species of insects, birds and reptiles.

According to the report, the fate of so many brownfield habitats in such a short period shows that "*the rate of development on brownfields is highly unsustainable, putting rare and endangered species at risk of local or national extinction*". The report calls for greater protection and consideration of brownfield habitats in the UK, arguing that "*the planning system does not deliver safeguards for brownfield habitats and invertebrates of conservation concern*".

Recommendations in the report are aimed at encouraging local and national authorities to place more protection on brownfield sites. In summary the report proposes:

- A higher level of protection for brownfield sites of biodiversity value to ensure these are not developed.
- A UK wide inventory of Open Mosaic Habitat to be developed and held by the appropriate statutory body. This has already partly been developed for some regions of the UK (e.g. North East and Midlands).

And for local authorities in particular:

- A definition of 'high environmental value' within their Local Plans or associated guidance.
- A landscape and strategic approach to brownfield re-development. Local authorities should identify areas of open mosaic habitat on previously developed land within their authority boundary and designate important sites. Areas of low environmental value can be put forward for development.
- Brownfield sites to be assessed using Open Mosaic Habitat criteria and the appropriate invertebrate surveys carried out in advance of planning decisions to inform development control decisions.

Reference

Robins, J. (2013). The state of brownfields in the Thames Gateway. Buglife. Peterborough, UK., 15 pp; available at: https://www.buglife.org.uk/sites/default/files/%20State%20of%20brownfields%20in%20the%20Thames%20Gateway_Jamie%20Robins,%20Buglife.pdf

Sochi: another Olympic story of habitat destruction

The London Olympic Games were an undoubted success in many respects but the brownfield habitats at the main site in the lower Lea Valley, east London were obliterated (see *ICN* No. 52). The official story was that the site had been an entirely derelict, contaminated, wasteland and that the Olympic project was creating new habitats, thus providing new value for wildlife. There was certainly habitat creation, at considerable expense, but there was never any attempt to assess the value of the habitats that were obliterated. They simply didn't exist, according to the authorities.

It can be argued that brownfield habitats are inherently replaceable, albeit without much prospect of re-establishing all the rare species that some of them support. No such argument can apply to pristine habitats, such as exist in parts of the north and west Caucasus Mountains and the nearby shores of the Black Sea. Yet, according to reliable sources, such habitats were seriously damaged during the construction of facilities for the 2014 Winter Olympics in Sochi, southern Russia. Much of the damage reportedly occurred in a biosphere reserve, which is home to many rare plants and animals.

The biosphere reserve comprises a variety of natural ecosystems, representing most of the ecosystem types of the Great Caucasus, including belts that range from subtropical to glacial and nival. Species endemism is frequent but most of the readily available information concerns plants and vertebrates, rather than invertebrates. In the region as a whole, there are rare invertebrates such as the butterfly *Allancastria caucasica*, the predatory bush cricket *Saga pedo* and the longhorn beetles *Rosalia alpina* and *Cerambyx cerdo* (Anon., 2000; Zazanashvili & Mallon, 2009). Of especial interest are the invertebrates of the nearby Krubera-Voronja Cave, the deepest explored on earth. The cave entrance is only about 20 km from the Olympic Park but lies within the territory of Abkhazia, which was formerly governed by the neighbouring Republic of Georgia.

Some of the invertebrate species of the Krubera-Voronja Cave can also live on the surface but survive in the cave during adverse conditions. The others are highly specialised cave inhabitants (troglobionts), which include the leech *Erpobdella absoloni ratchaensis*, the slug *Troglolestes sokolovi*, harvestmen of the genus *Nemaspela*, the endemic millipedes *Leucogeorgia* spp. and *Archileuco georgia*, the amphipod *Zenkevitchia*, the shrimp *Troglocaris schmidti fagei*, the springtail *Plutomurus ortobalaganensis* and the endemic ground-beetles *Jeannelius* spp. (Sendra & Reboleira, 2012).

There is no report of disturbance of the Krubera-Voronja Cave, which lies in the Ortobalagan valley, feeding its subterranean waters into springs on the coast near Sochi. Severe disturbance has, however, occurred in the valley of the Mzymta River, which also flows towards Sochi and is the largest of the rivers on Russia's Black Sea coast. The valley of the Mzmyta connects the two main Olympic clusters: one on the subtropical coast (for ice rink-based events) and the other in the mountains (for skiing, snowboarding, bobsledding, and other events).

Between the two Olympic clusters, access along the valley of the Mzmyta was improved by the upgrading of a road and the construction of a railway, requiring tunnels and bridges across rugged terrain. The construction work reportedly involved the felling of thousands of beech trees *Fagus orientalis*. According to an official monitoring report, much of the Mzmyta was "*transformed from a clean, white-water river into a controlled waterway, tainted by chemical pollutants and debris*". The river was previously the spawning site of one-fifth of Russia's valuable Black Sea salmon.

In March 2011, there was a declaration that the ecosystem of the Mzymta River basin would be restored "conjointly" by the main companies involved in the Olympics, in co-operation with the regional administration of Krasnodar. Then, in 2012, a post-Olympic environmental rehabilitation programme costing around 1 billion roubles (20 million pounds sterling) was developed by leading Russian scientists and international experts from International Union for the Conservation of Nature and the United Nations Environment Programme but the Russian government has reportedly refused to fund the programme.

When the scale of the destruction became evident, the Worldwide Fund for Nature (WWF) and Greenpeace withdrew from a government-led oversight commission. In a position statement, WWF in Russia has explained the reasons for its withdrawal, which included not only the degradation of the Mzymta River but also the logging of more than 3,000 hectares of ancient forest, containing large numbers of yew *Taxus baccata* and box *Buxus sempervirens*. Interestingly, the WWF-Russia position statement mentions that WWF-UK helped write London 2012's 'One Planet Olympic' sustainability framework and remained a prominent stakeholder adviser throughout the 8 year process of planning and implementing the 'greenest Games ever'. The position statement can be found at: http://www.wwf.ru/about/positions/sochi2014/eng

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Anon. (2000). Group of Experts on Conservation of Invertebrates: Convention on the Conservation of European Wildlife and Natural Habitats. Report of meeting, Neuchâtel Switzerland, 13 May 2000.

Sendra A. & Reboleira A.S.P.S. (2012). The world's deepest subterranean community – Krubera-Voronja Cave (Western Caucasus). *International Journal of Speleology* **41**, 221-230.

Zazanashvili, N. and Mallon, D. (Eds.) (2009). *Status and Protection of Globally Threatened Species in the Caucasus*. Tbilisi: CEPF, WWF, Contour Ltd., 232 pp.

Decline of grassland butterflies across Europe

The European Grassland Butterfly Indicator 1990-2011 (European Environment Agency, 2013) is a report based on national Butterfly Monitoring Schemes in 19 European countries. The report, which is the second version of a multi-author work first published in 2005, indicates that butterfly populations declined by almost 50% in the period 1990 to 2011 according to a standardised index. The data since 2005 continue the trend revealed in the previous report.

Seventeen indicator species are covered by the monitoring schemes used in the report. With the proviso that the results are influenced by the enlistment of additional countries during the survey period, it is concluded that the European populations of seven of these species

have undergone a moderate decline. These are all butterflies found in Britain: Common Blue (*Polyommatus icarus*), Meadow Brown (*Maniola jurtina*), Dingy Skipper (*Erynnis tages*), Small Heath (*Coenonympha pamphilus*), Wall (*Lasiommata megera*), Small Copper (*Lycaena phlaeas*) and Large Blue (*Maculinea arion*). Of the other ten, one (*Phengaris arion*) has undergone a steep decline, two (*Anthocharis cardamines* and *Polyommatus bellargus*) have remained stable, one (*Spialia sertorius*) has moderately increased and the following six are of uncertain status: *Euphydryas aurinia, Ochlodes sylvanus, Cyaniris semiargus, Cupido minimus, Polyommatus coridon* and *Thymelicus acteon*.

The authors of the report suggest that the main driver behind the declines is the "*change in rural land use: agricultural intensification where the land is relatively flat and easy to cultivate, and abandonment in mountains and wet areas, mainly in eastern and southern Europe*".

As seen widely in Britain, agricultural intensification can lead to a uniformity of grasslands, leaving them almost devoid of biodiversity. Grassland butterflies therefore survive mainly in traditionally farmed "High Nature Value" (HNV) areas, in nature reserves, roadside verges and gardens. The report also shows how the Common Agricultural Policy (CAP) is highly influential, since it assists farmers to work grassland of low productivity but high biodiversity which, if abandoned, quickly becomes overgrown and colonised by scrub and woodland. Removal of CAP subsidies can therefore support the presence of grassland butterflies in many upland and more arid areas of continental Europe and could also play a role in the UK.

Action to help the situation for European grassland butterflies does not seem difficult in principle but, in practice, it is subject to the complexities of EU policy and to debate in each country. Even if such action is approved, its implementation is likely to be slow. The summary of conclusions in the report includes the following:

- The EU Biodiversity Strategy recognises the poor conservation status of grasslands and of their characteristic butterflies. The actions set out in this Strategy need urgent implementation.

- Appropriate management is vital both for grasslands designated as Natura 2000 areas and on HNV farmland outside these areas. Financial support for biodiversity-friendly actions and programmes should also be further enhanced through the Common Agricultural Policy measures.

Reference

European Environment Agency (2013). *Technical Report* No. 11/2013, 34 pp: available at: http://www.eea.europa.eu/publications/the-european-grassland-butterfly-indicator-19902011)

RESEARCH NOTES

Toxicity of pesticides to different life stages of aquatic invertebrates

Recent debates about the effects of pesticides on non-target species have often focussed on the apparent unreliability of tests that underpin the official approval of particular products and their uses. In some instances, tests have been criticised for failing to measure sub-lethal effects on the non-target organisms. But, even if a range of sub-lethal effects are included in tests, there could still be indirect effects that are not properly taken into account, according to a Belgian group of research workers (Navis *et al.* 2013). They studied the effects of two insecticides on different life stages of the water flea *Daphnia magna*, a species that is widely used as an indicator of toxicity in aquatic environments.

There are two standard toxicity tests on *Daphnia* as an indicator: (a) the *Daphnia magna* Reproduction Test 1 and (b) the *Daphnia* sp. Acute Immobilisation Test 2 (OECD, 2004; 2012). Both tests begin

with *Daphnia* hatchlings, less than 24 hours old, which are observed for harmful effects over a specified period. The researchers suspected, however, that harmful effects might occur also in *Daphnia* that are exposed to pesticides while in the egg stage. As in many other aquatic invertebrates that are adapted to adverse conditions, such as the temporary drying-out of pools, a proportion of the eggs of *Daphnia* remain dormant (enclosed in cases known as ephippia) over successive growing seasons. The dormant 'egg bank' is effectively a kind of insurance against conditions that could wipe out a current generation of active individuals.

The research group tested pesticides on the eggs of *D. magna*, after removing the outermost layer in order to simulate conditions of maximum exposure, as might occur when pesticides are applied in the spring. Two pesticides were used in the tests: the neurotoxin carbaryl and the insect growth regulator fenoxycarb, which is widely used in orchards. Carbaryl is no longer registered for use in the EU but the research group tested it as a representative of the carbamate class of insecticides.

Even when applied at 1,000 times the concentration required to kill half a test population of new hatchlings, carbaryl did not impair egg development or hatching but it negatively affected the survival and the reproductive maturation of the hatchlings. Fenoxycarb completely prevented hatching of eggs at high concentrations and it delayed hatching at lower concentrations. It also caused developmental abnormalities, while additionally affecting the survival and reproduction of hatchlings, similarly to carbaryl.

The researchers suggest that the delayed effects of low concentrations of pesticides could affect population growth rates in aquatic invertebrates like *Daphnia*, with consequent effects on ecosystems. They mention, for example, that depletion of the *Daphnia* population could affect fish as predators, while allowing algae to build up because of reduced grazing by *Daphnia*. They argue, therefore, that eco-toxicity testing should involve all the life-cycle stages of indicator species. Also, they mention the need to take account of the processes that expose invertebrates to pesticides, for example where these toxins are adsorbed on to particles of sediment.

References

Navis, S., Waterkeyn, A., Voet, T., *et al.* (2013). Pesticide exposure impacts not only hatching of dormant eggs, but also hatchling survival and performance of the water flea *Daphnia magna*. *Ecotoxicology*, **22**, 803-814.

OECD (2004). Guidelines for the Testing of Chemicals, Section 2, Test No. 202: *Daphnia* sp. Acute Immobilisation Test http://www.oecd-ilibrary.org/environment/test-no-202-daphnia-sp-acute-immobilisation-test_9789264069947-en

OECD (2012). Guidelines for the Testing of Chemicals, Section 2, Test No. 211: *Daphnia magna* Reproduction Test http://www.oecd-ilibrary.org/environment/test-no-211-daphnia-magna-reproduction-test_9789264185203-en

Pesticide toxicity: interactions with environmental factors

The article above indicates cause for concern about toxicity tests that fail to take account of the exposure of different life-cycle stages of the species concerned. Another possible problem with standard tests is a potential failure to allow for the effects of environmental factors that can influence the impact of pesticides on non-target species.

In recent research by a Canadian group (Alexander *et al.*, 2013) bottom-dwelling macro-invertebrate communities were exposed to a mixture of pesticides under a range of nutritional conditions. The species under test were taken from local streams and included non-biting midges (*Chironomus* spp.). The pesticides were chlorpyrifos, dimethoate and imidacloprid, which are used in agriculture and are toxic to non-target species. The last named is one of the neonicotinoids now temporarily restricted in the European Union because of concern about possible harm to bees and other pollinators.

The study involved various combinations of naturally obtained oligotrophic water (containing low nitrate levels) and mesotrophic water (i.e. containing moderate amounts of nitrate) and different concentrations of the pesticide mixture. These treatments were established in a total of 80 outdoor artificial streams, which were fed with natural groundwater from the area and made to flow over beds of stone and gravel coated in an algae film in order to simulate natural conditions. Also, various locally occurring predators: dragonflies (*Gomphus* spp.) and stoneflies (*Agnetina* spp.) were added to the streams in order to simulate natural stress on the communities under test.

Since algal growth was enhanced by nitrate-enrichment, the macro-invertebrate populations increased more in the enriched streams than in the unenriched streams where pesticides were either not added or added only at a low (sublethal) concentration. But when the pesticide concentration was high enough to cause a decline in the numbers of invertebrates, this adverse effect was greater in the nitrate-enriched streams and also varied between the different species according to the dose of insecticides. Predation by the dragonflies and stoneflies had a significant effect only in the unenriched streams.

These results indicate some difficulty in predicting the effects on aquatic organisms of complex mixtures of pesticides, commonly used in agriculture, particularly when streams and rivers are moderately enriched with nutrient inputs from the surrounding landscape.

In a related study, a German group looked at interactions between pesticides and the effect of competition between different aquatic invertebrates (Liess *et al.*, 2013). The group set up populations of the water-flea *D. magna* and of larvae of the mosquito *Culex pipiens* in 5.5 litre containers in the laboratory, in which natural conditions were simulated, with the regular addition of food suitable for both species. These two species compete with each other in the wild. Two thirds of a total of 36 of these "nanocosms" contained both species, while the remainder contained only *C. pipiens*.

Over a period of 277 days, the nanocosms were treated on five occasions, each lasting 24 hours, with doses of the pesticide thiacloprid, a neonicotinoid insecticide used against insects such as aphids and whiteflies. This was administered at three concentrations: 3.3 μg/l (micrograms per litre), 10 μg/l or 33 μg/l concentrations. The researchers used a photographic method in order to estimate the number of mosquito and/or water-flea larvae present from the images. The results showed no effects of the pesticide on the water-fleas but the mosquito larvae were adversely affected at all three concentrations.

Although the populations of the mosquito larvae declined after exposure to thiacloprid, they recovered in between the sequential doses where they were not competing for food with the water-fleas, except at the highest dose (33 μg/l). When, however, the two species were kept together, they did not recover to pre-treatment levels and they showed an overall decline during the study.

The results have been interpreted as showing that sub-lethal doses of a pesticide can alter the ability of a more susceptible species to compete for food with a less susceptible species. If so, the impact of pesticides on invertebrate communities – perhaps terrestrial as well as aquatic – could be more complex and far-reaching than might be assumed on a more simplistic basis. Members of the same research group in Germany previously found deleterious effects of another pesticide, esfenvalerate, on *Daphnia* spp. in the presence of competitive species (Knillmann *et al.*, 2012).

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Plastic particles: effect on lugworms and other marine invertebrates

There is increasing concern about the harmful effects of 'microplastic particles' in marine environments. These particles, which are defined as no more than 1 mm in size, pass through filters designed to remove solids from waste water. They are estimated to have become the most abundant form of solid-waste pollution on Earth. They consist of various plastics, such as polyethylene, polyvinyl chloride (PVC), polystyrene and polyesters. A large proportion of them carry toxic additives, including dyes and anti-microbial chemicals. Also, they can adsorb toxins that are already present in seawater.

Since microplastic particles can mix with marine sediments, there is concern that they could be harming marine invertebrates, such as lugworms, sea cucumbers and fiddler crabs, that ingest or sift sediment in order to extract food particles. Plastics in the bodies of such invertebrates can move through the food chain when these species are eaten by predators, including seabirds and bottom-feeding fish.

Research workers at the Universities of Exeter and Plymouth in the UK have found that lugworms (*Arenicola marina*) in marine sediment highly contaminated with PVC particles showed less gain in weight than worms in clean sediment (Wright *et al.*, 2013). The low weight of affected worms reflected impaired feeding activity, which has implications for the important ecological role of lugworms in the turnover of sediment. They can comprise up to 32 percent of the mass of the shoreline biota. The worms in the contaminated sediment also had as little as half the normal energy required for key processes such as growth and reproduction.

Some of the same UK researchers, in collaboration with colleagues at the University of California, Santa Barbara (Browne *et al.*, 2013), have shown that *A. marina* absorbs chemicals carried by PVC microparticles, including the pollutants nonylphenol and phenanthrene and the additives triclosan (an anti-microbial) and pentabromodiphenyl ether (a flame retardant). Results showed that the tissues of the worms contained such substances at concentrations sufficient to impair key physiological functions. This finding has implications for the health and reproductive success of predators in the food chain, including human beings who eat fish and other seafood.

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Printed by: The Lavenham Press Ltd, Arbons House, 47 Water Street, Lavenham, CO10 9RN.